Getting Students Excited about Data Analysis

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Abstract: *The Graphing Art Project encourages students to explore functions as they create art. Students write functions with domain and range restrictions that generate interesting pictures. The project is easily tailored for different levels of mathematical learners. Algebra 1 students create art using linear functions; precalculus students include conic sections, exponential, logarithmic, trigonometric functions and the greatest integer functions in their work. Students may write graphing calculator programs to reproduce and animate their art.*

Keywords. *Function, art, graphing, multiple representations*

1 Introduction

The *Guidelines for Assessment and Instruction in Statistics Education* (GAISE), written jointly by the American Statistical Association and the National Council of Teachers of Mathematics, addresses the need for all adults to be statistically literate (Franklin et al, 2007; NCTM, 2000). The report provides guidelines for enabling all students to develop statistical literacy by the time that they become adults. However, for students to achieve such an end, statistical education must begin in elementary school. In the main body of the paper, we refer to the GAISE levels, which are developmental statistical levels. However, as noted in the conclusions, these developmental levels correspond roughly to the more specific standards addressed in the *Core Curriculum Standards for School Mathematics* (CCSSI, 2010).

Ms. Angel was interested in the statistical learning of her third-grade students and in learning to use technology appropriately in her classroom. She decided to guide her students through a statistical investigation and asked the following questions:

1. Why should third-grade students carry out such an investigation?
2. With guidance can third-grade students carry out a statistical investigation?
3. What does developing and completing a statistical problem involve?

The GAISE report, in particular level A, the developmental level for beginning data analysis, addresses the first question: in order to obtain statistical literacy, students must begin in elementary school with a gradual introduction to understanding the statistical process. This part of the report helped her understand not only how to perform a statistical investigation, but also why her students needed to learn how to ask a question and collect and analyze data to answer it. Furthermore, she could then guide her students through their statistical problem solving at the right developmental level.

According to the GAISE, statistical problem solving is an investigative process that involves four components, though the sophistication of the investigations vary with regard to level of students:

1. Formulate Questions - formulate one (or more) questions that can be answered with data.
2. Collect Data
   - design a plan to collect appropriate data
   - employ the plan to collect the data
3. Analyze Data
   - select appropriate graphical or numerical methods
   - use these methods to analyze the data
4. Interpret Results
   - interpret the analysis
   - relate the interpretation to the original question (GAISE, p. 9)

TinkerPlots® is a data analysis software allowing students to enter data in a table and to create dot plots and bar graphs from the data. Using the GAISE investigative process, Ms. Angel worked with her 20 third graders to consider the weight of elementary students' book bags and to collect and interpret data regarding book bag weights of first through fifth grade students at their school.

2 Formulate Questions

Ms Angel asked her third-grade class to think about typical student book bag weights and comparisons of weight between grade levels and genders. Note that the teacher posed a question of interest to the students and the question was not restricted to their own classroom. Furthermore, the teacher asked students to consider variability of the data by asking them to think about comparisons between grade levels and genders. She placed the students into five small groups to think about the answer. The groups reported that they thought book bags would weigh: 13 lbs, 105 lbs, 5 lbs, 2 lbs, and 12 lbs. All groups hypothesized that fifth graders would have heavier book bags because they have more work and carry more "stuff" around. They believed boys had heavier book bags for various reasons: boys have a lot of stuff, boys put CDs in their book bags, boys usually have more things, and boys are stronger. To expand the number of participants in the study, the third graders included students outside their own classroom.

To solve the problem of who had the heaviest book bags, the class broke down the question into subquestions that they would be able to answer from the data they could gather. The students decided they wanted answers to the following questions:

1. How much do students' book bags weigh?
2. Which students, first through fifth graders, carry the heaviest book bags?
3. Are girls' book bags heavier than boys' bags or vice-versa?

3 Collect Data

The five groups were excited to visit each classroom in grades 1 through 5 in their school to find out if their conjectures were true. Each group was assigned one grade level for collecting data. They read letters to the classes to introduce themselves and to explain the project.

Students were taken one by one into the hall to gather data. The following data were recorded in a table provided by their teacher: a number for each student instead of an actual name, gender, grade, body weight, and weight of the child wearing their book bag. After collecting data, students

Hi, we are _____ ,_____ , _____ , and _____ from Ms. Angel's third grade class. We are doing an experiment on the weight of book bags. We want to find out how much book bags weigh, which grade has the heaviest book bags, and do girls or boys have the heaviest book bags. We would like to weigh each of you and then weigh you with your book bag to find out the weight of the book bag. Thank you for helping us with our experiment.

Fig. 1: *Letter for collecting data.*

needed to take one more step and compute the weight of the book bag by subtracting student weight from the weight of the same student wearing a book bag. As appropriate for GAISE level A for beginners, the students obtained data from all of the students in each class rather than taking a random sample of students by grade.

4 Analyze Data

After collecting the data, each group entered their own data into TinkerPlots® while the teacher helped them to investigate the software and make various graphs of the data. TinkerPlots® allows one to use an actual descriptor as a variable name, such as `maleorfemale`. Since each group focused on one grade level, their data pertained only to that grade. Grade-level work included tables of gender and book bag weights as shown in Fig 2.

	maleorfemale	Bookbag_Weight
unit		Pounds
1	male	2.1
2	female	4.0
3	female	2.4
4	female	3.7
5	male	4.9
6	male	4.3
7	male	11.2
8	male	4.6
9	female	6.9
10	female	6.0
11	female	0.7
12	female	8.2
13	male	7.9
14	male	4.2
15	female	6.3
16	male	11.0
17	male	4.9

Fig. 2: *Table of data of gender and book bag weights from grade 3.*

As Fig 3 shows, dot plots of bag weight were also generated.

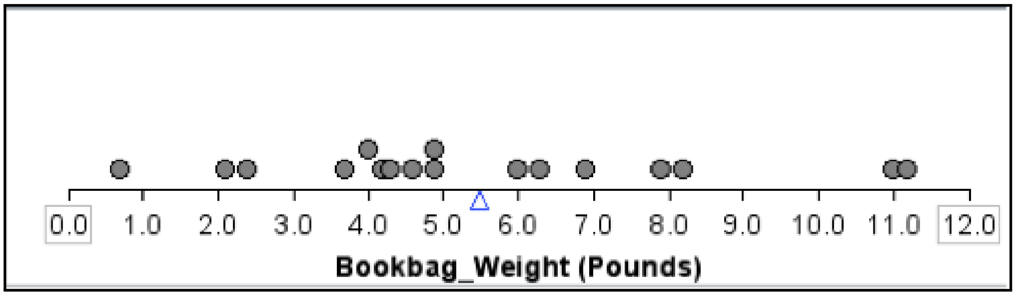

Fig. 3: *Dotplot of book bag weights for grade 3.*

Dot plots of bag weight separated by gender were also created, as shown in Fig 4.

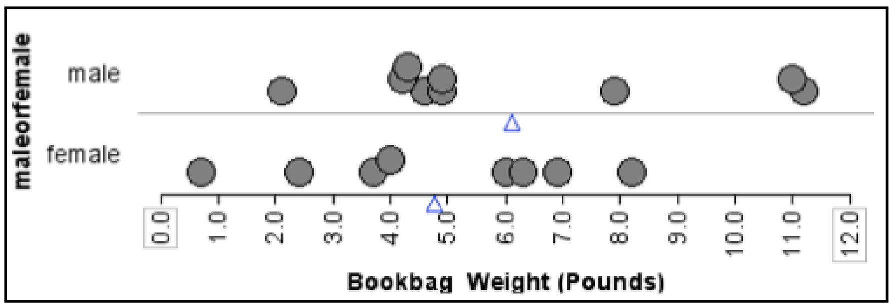

Fig. 4: *Dotplot of book bag weights separated by gender.*

The table and graphs come from the work of the group who investigated the 17 third graders. The small triangles on the dotplots represent the average (mean) for the book bag weight variable. TinkerPlots® can also produce bar charts and circle graphs for categorical data.

This hands-on experience within their groups helped the students understand the graphs of their own data before it was combined with data from all the groups. Once the whole class was brought together, the teacher created a table to display the data for all 96 children in grades 1 through 5. Together, the teacher and students created various graphs of these combined data: dotplots of bookbag weights (Fig 5), bookbag weights separated by grade (Fig 6), and bookbag weights separated by gender (Fig 7).

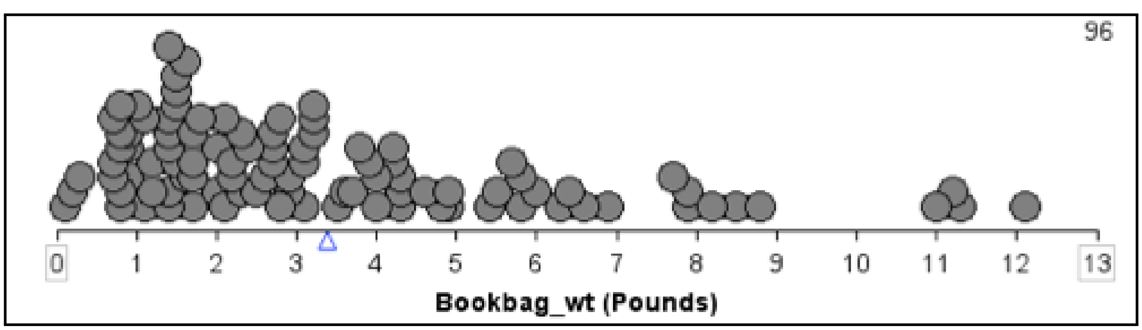

Fig. 5: *Book bag weights for all students in grades 1 through 5.*

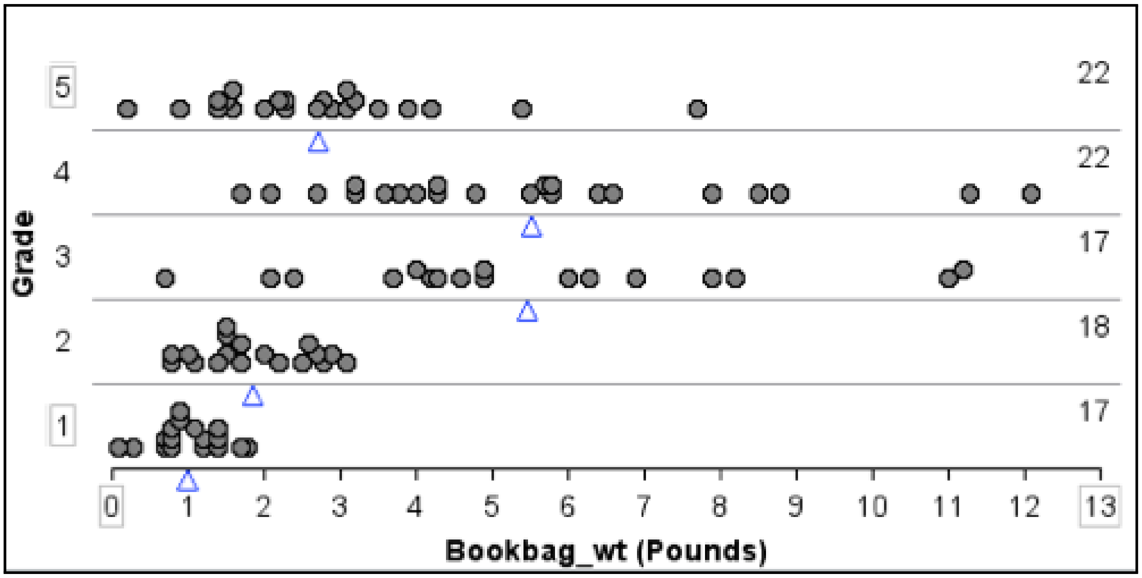

Fig. 6: *Book bag weights by grade level.*

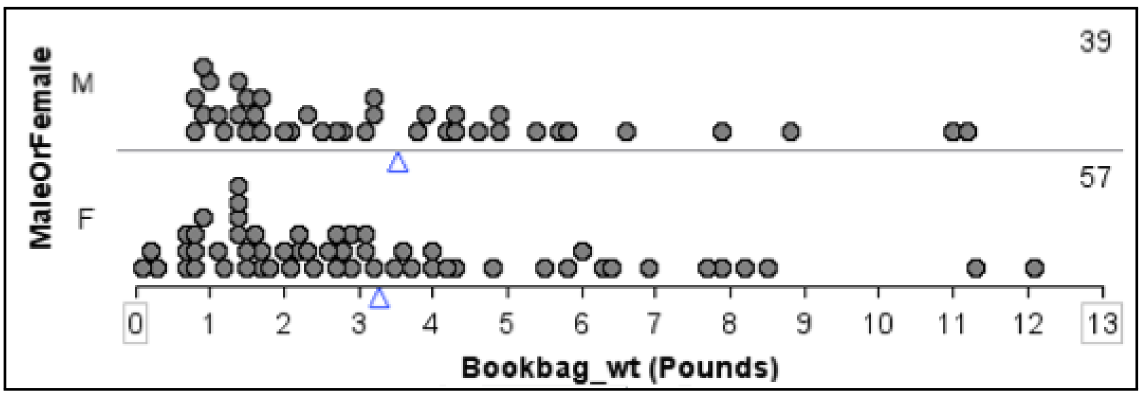

Fig. 7: *Book bag weights by gender.*

5 Interpret Results

The teacher then led a discussion of the three dotplots: book bag weight of all levels, grade level vs book bag weight, gender vs book bag weight. The students noticed that the average weight of a book bag for all levels was between 3 and 4 pounds. Two groups had been close with their conjecture of 2 lbs and of 5 lbs For the second question about grade level book bag weights, the students noticed it was actually 4th graders who had heavier book bags. The students interpreted this data to mean that either 4th graders had homework the night before or that they were just getting used to having four teachers giving homework of which they had to keep track. For the final question about gender and book bag weight (all groups previously thought boys would have heavier book bags), they noticed that boys did have a heavier book bag average but not by much. The averages for book bags of both the boys and the girls were between 3 and 4 pounds, but the boys' book bag weights were farther to the right on the graph, so their average was heavier.

6 Assessing Students' Understanding

For informal pre- and post-activity assessments the teacher provided students a dotplot of book bag weights separated by grade level. The post assessment showed that all students recognized the graph was showing who had the heaviest book bags, and students were now able to explain that by studying the graphs they could determine that boys' book bag weights were only slightly more than girls' book bag weights. It looked as though fourth graders had the heaviest book bag, because there were more book bags at the heavier weights (to the right on the graph).

7 Conclusions

From studying the GAISE, Ms. Angel realized that all students who graduate from high school should be able not only to read tables and graphs presented to them in the media every day, they should also be able to ask and determine if the graphs accurately represent the data. Furthermore, if the data aren't included in the presentation, the students should know that they can find data and analyze it themselves to determine if the claims are justified. In order to have these skills by high school, they must start in elementary school. Through helping her students ask questions about topics of interest to them, and then gather the data to answer the questions, she concluded that third graders can carry out a statistical investigation at their appropriate developmental level. To do this, the students were guided first with appropriate questions. She then guided her students though collecting data, analyzing the data, and interpreting the results.

In addition to answering her research questions, Ms. Angel found that her students became more interested in a project when they were involved in the whole process they got to be involved in decisions, data collection, and analyzing what the data meant. Students were excited because part of it happened outside of classroom, while gathering data from all of the students in the school. Students were more interested because the whole process of statistical problem solving was used and not just one isolated piece.

Although TinkerPlots® was difficult for the students to understand, they were able to enter their data into the tables and the graphs used as a whole class helped the student to answer their questions about book bag weights. They thus found that they could find the answers to their questions and did not have to rely on someone to tell them.

8 The Investigation within the Framework of the Core Curriculum Standards for School Mathematics

The *CCSSM* (CCSSI, 2010) highlight individual parts of a statistical investigation and state in which grade students should experience part of an investigation. For example, in first grade, students should be able to organize and represent data with up to three categories. Second graders need to generate measurement data by measuring lengths and work with bar graphs. Third graders should be able to represent several categories of data with scaled picture graphs and scaled bar graphs. During the investigation about student book bags, the third-grade students were focused on obtaining answers to their questions and, with the teacher's help and using Tinkerplots®, created tables and dot plots of the data. The whole class then studied these graphs and were surprised to find that the results were not quite what they initially believed.

References

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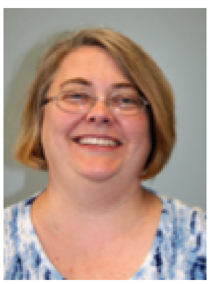

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